TEQ Training & Consulting GmbH | Dr. Wolfgang Schultz| September 2016

What Does SPC Actually Mean? - A Brief Overview

1 Definition

Some people like to translate SPC as “show program for customers”, which implies that it has obviously something to do with pictures. SPC thus tries to show customers that the processes manufacturing their products meet the respective requirements reliably. Since each product includes specific characteristics, SPC is all about proving capability numerically based on measured values and showing the results in clear graphics. SPC actually means statistical process control. But what is actually part of statistical process control and what is not? Opinions differ. Some users think that statistical process control is restricted to the application of quality control charts. They consider the previously needed analysis of the distribution, its statistics and stability to be prerequisites but do not include these pieces of information.

Booklet 7 “Statistical Process Control SPC“ of Robert Bosch GmbH provides a perfect example.

1. Terms for Statistical Process Control

Process
A process is a series of activities and/or procedures that transform raw materials or pre-processed parts/components into an output product.
The definition from the standard [3] is: “Set of interrelated or interacting activities which transforms inputs into outputs.”
This booklet only refers to manufacturing or assembly processes.

Stable process
A stable process (process in a state of statistical control) is only subject to random influences (causes). Especially the location and variation of the process characteristic are stable over time (refer to [4])

Capable process
A process is capable when it is able to completely fulfill the specified requirements. Refer to [11] for determining capability indices.

Shewhart quality control chart
Quality control chart for monitoring a parameter of the probability distribution of a characteristic, in order to determine whether the parameter varies from a specified value.

SPC
SPC is a standard method for visualizing and controlling (open or closed loop) processes, based on measurements of random samples.
The goal of SPC is to ensure that the planned process output is achieved and that corresponding customer requirements are fulfilled.

SPC is always linked to (manual or software supported) use of a quality control chart (QCC). QCC´s are filled out with the goal of achieving, maintaining and improving stable and capable processes. This is done by recording process or product data, drawing conclusions from this data and reacting to undesirable data with appropriate actions.

In search of supplementary information, you are likely to “google“, which leads you to Wikipedia, at least in most cases. As of 23 February 2016, 11:13 a.m., you will find the following information:

“...is a method of quality control which uses statistical methods. SPC is applied in order to monitor and control a process. Monitoring and controlling the process ensures that it operates at its full potential. At its full potential, the process can make as much conforming product as possible with a minimum (if not an elimination) of waste (rework or scrap). SPC can be applied to any process where the „conforming product“ (product meeting specifications) output can be measured. Key tools used in SPC include control charts; a focus on continuous improvement; and the design of experiments.”

The main aspect behind the description given above is that SPC is applied in a much wider context than just the use of quality control charts. It is also worth mentioning the previous process analysis – typically including machine and process capability analysis, shape of distribution, stability and capability indices.

Another extract of this article says: “SPC was pioneered by Walter A. Shewhart at Bell Laboratories in the early 1920s. Shewhart developed the control chart in 1924 and the concept of a state of statistical control.” The fundamental issue is that Shewhart discovered that the sources of variation of characteristic values in a series production process fall into two different classes.

- Random causes (normal sources of variation, stochastic process, random noise)
- Special (or “assignable“) causes – systematic causes (different batches of material, machine settings, tool wear, etc.)

There are two common mistakes when trying to reduce variation:

- Type I error: A deviation is assigned to a special cause even though its origin was a random cause.
- Type II error: A deviation is assigned to a random cause even though its origin was a special cause.

In order to distinguish these two sources of variation from each other and to minimise the number of errors, Shewhart developed “control charts“. Beyond doubt, they are the core element of statistical process control. However, I would like to repeat again that you can only apply quality control charts when you calculated them based on a previous process analysis.

Within the scope of the national and international standardisation for applied statistics, the term SPC is associated with process control and process improvement. ISO 3534-2 defines:

2.1.8
statistical process control
SPC
activities focused on the use of statistical techniques to reduce **variation** (2.2.1), increase knowledge about the **process** (2.1.1) and steer the process in the desired way

NOTE 1 SPC operates most efficiently by controlling variation of a process characteristic or an in-process product **characteristic** (1.1.1) that is correlated with a final product characteristic and/or by increasing the robustness of the process against this variation. A supplier’s final product characteristic can be a process characteristic to the next downstream supplier’s process.

NOTE 2 Although SPC originally was concerned primarily with manufactured goods, it is also equally applicable to processes producing services or transactions, for example, those involving data, software, communications and movement of material.

NOTE 3 SPC involves both **process control** (2.1.6) and **process improvement** (2.1.7).

Further definitions in ISO 3534-2 refer to the related process analysis under 2.1.10 as well as random and special causes of variation, stability and process capability under 2.2.

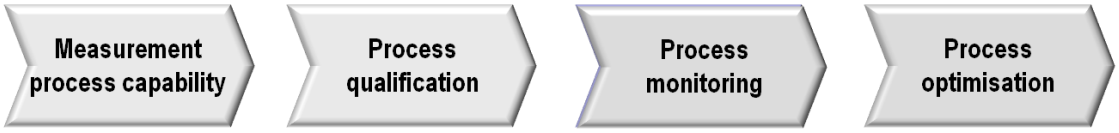
2 Phases

Based on the definitions mentioned above, I would like to give you a short overview of the main phases of SPC and the methods and procedures included.

2.1 Measurement process capability

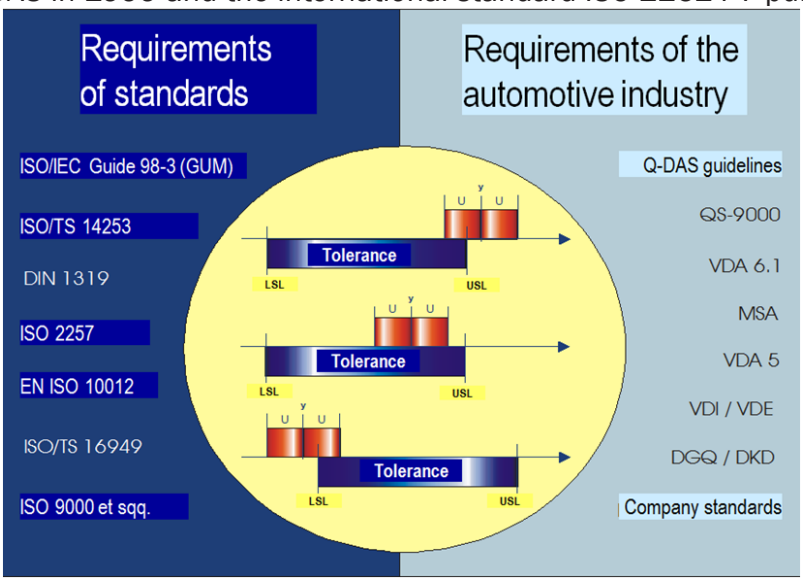
The essential requirement for process analysis and control is a suitable measurement process consisting of the test system applied for a specific inspection task and its integration into the entire

inspection task. There are numerous well-established procedures available for a process analysis and all of them are described in international standards, industry and company guidelines.



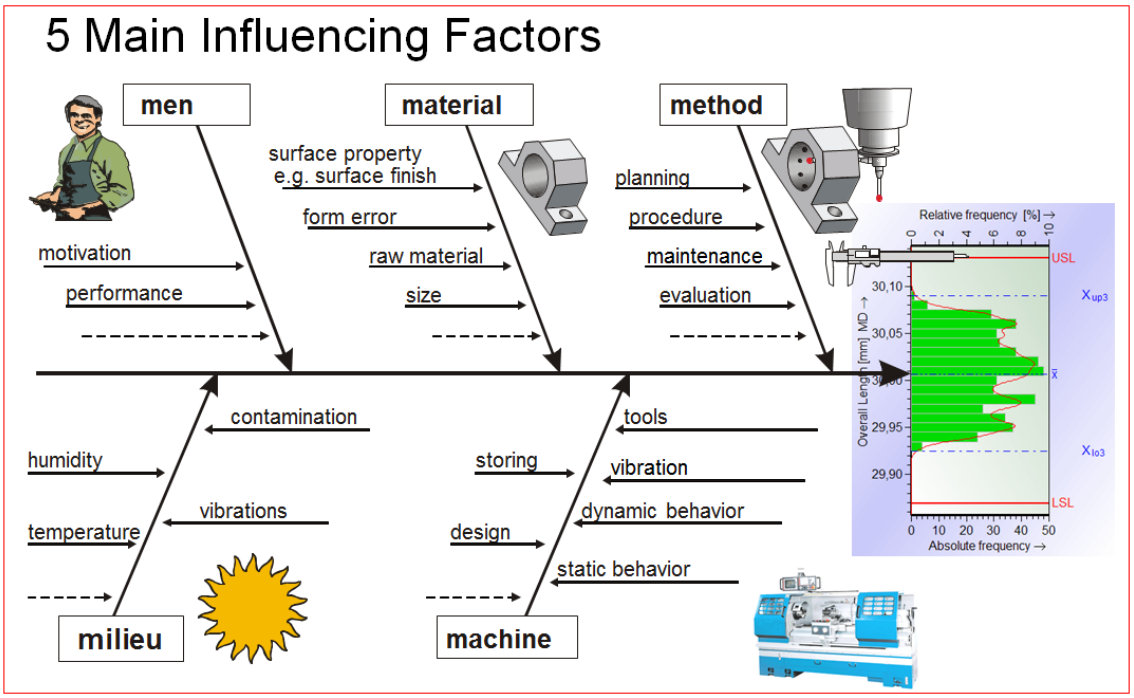
The most established and widely used ones are VDA Volume 5, AIAG's MSA 4th edition, the "Measurement System Capability" reference manual developed by a working group of the automotive industry headed by Q-DAS in 1999 and the international standard ISO 22514-7 published in 2012.

- Measurement system capability
- Measurement uncertainty
- C_g, C_{gk}; %GRR
- VDA 5, MSA, GUM



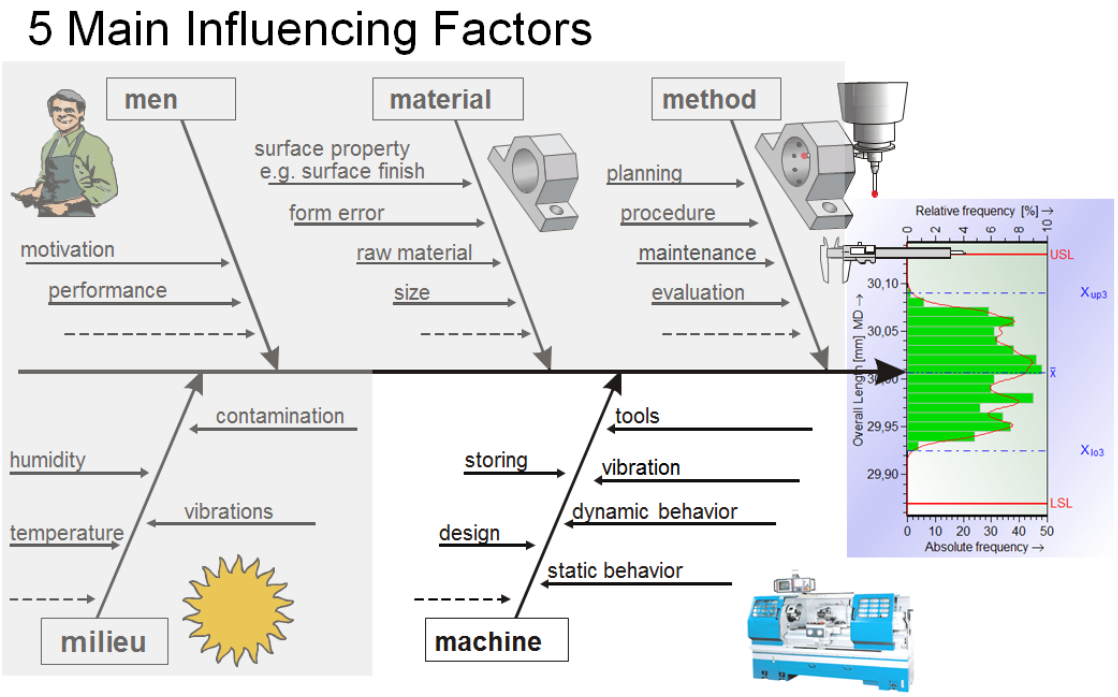
2.2 Process qualification

The actual manufacturing process is subject to many influences. Most of them are illustrated in an Ishikawa diagram.



The phase of process qualification is typically a two-stage process. The first stage helps to find the ideal performance of the machine (or manufacturing equipment – it does not have to be a "machine", it can also be a filling device or a technical process). This phase does not consider any influences other than the actual machine, i.e. it eliminates other influences or keeps them constant.

- **Only random influences** affect the variation caused by the machine (production facility), any other influences are kept constant.
- Sample size: You take a sample of **50 consecutive parts** within a short period of time.
- The target is to provide evidence that the machine (production facility) reliably produces parts not exceeding the tolerance limits.

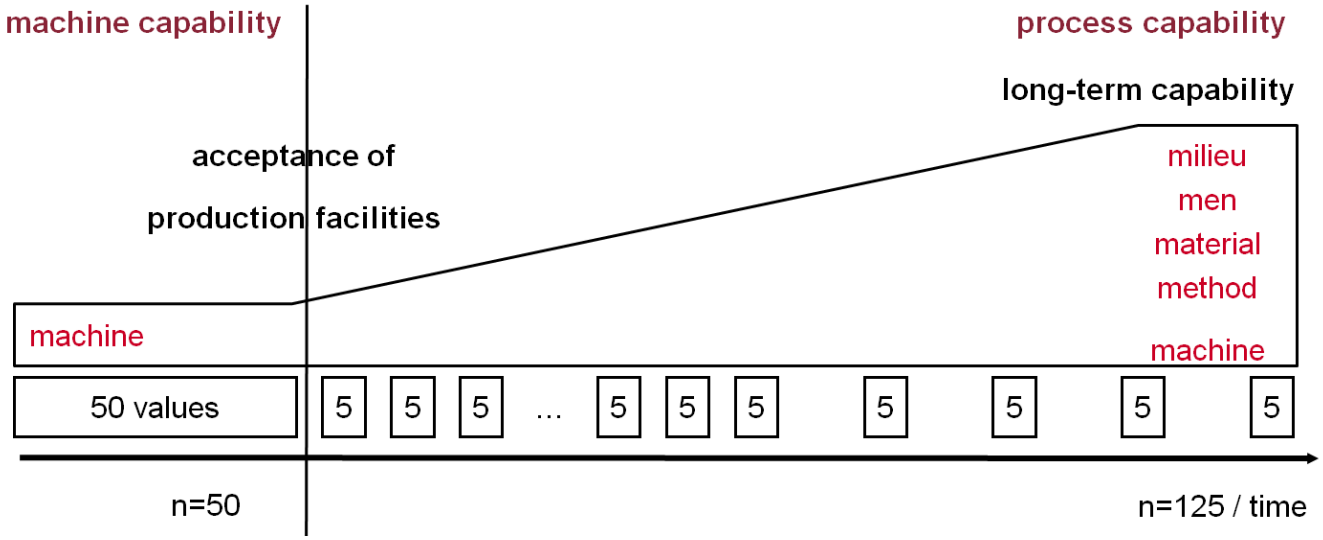


The next step is to analyse the whole process. All the influences shown in the graphic become effective.

- All influences characterising the production process affect the period under observation: milieu, men, material, method, and machine (the classical 5-M method, e.g. change of shift, change of batch, tool change, temperature fluctuations).
- Sample size: You typically take **25 subgroups**, each one including 5 values in a **"representative" period of time**. A total of 125 values are at least required.
- The target is to provide evidence that the process **permanently and reliably** produces parts **not exceeding the tolerance limits**.

The relationship between these two stages is described in the following.

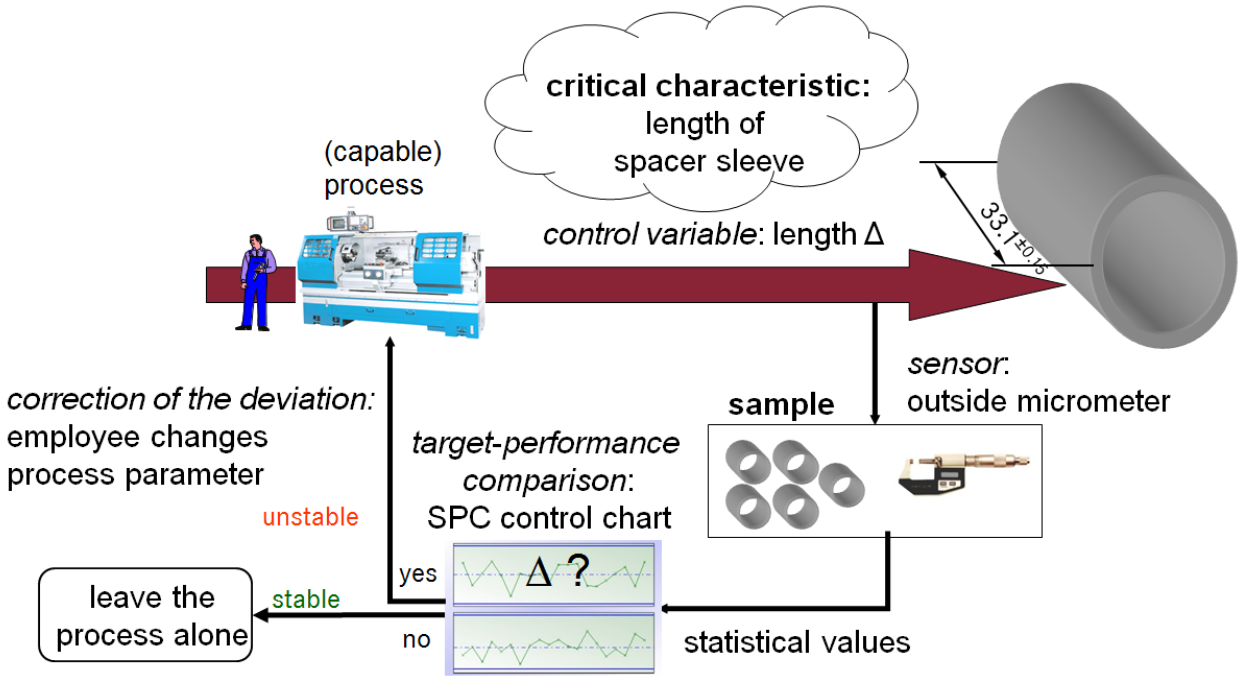
- The **short-term** or **machine capability analysis** evaluates the best possible performance of the process (C_m and C_{mk}).
- The **long-term** or **process capability analysis** evaluates the real performance of the process (P_p / P_{pk} or C_p / C_{pk}).
- The difference between machine and process capability analysis leads to the maximum potential for improvement that you can **theoretically** reach.



The graphic displayed above illustrates the relationship between machine and process capability. Detailed information about machine and process capability is provided in the article "Process Capability – a Simple Illustration".

2.3 Process monitoring

No matter which definition of SPC you apply, the phase of process control / process monitoring is about keeping the process on track with the help of samples, i.e. proving its stability or identifying and correcting deviations in time. As mentioned before, you apply quality control charts in order to do so. This refers to the small SPC control loop.



2.4 Process optimisation

In the phase of process optimisation, you analyse the data obtained in the previous phases in order to find suitable measures improving the process. These measures might focus on the reduction of short-term variation or- which is more often the case in practice – on the improvement of long-term

process stability. Tools such as design of experiments DoE or Six Sigma help to collect additional data indicating room for improvement, e.g. by showing ideal parameter settings.

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